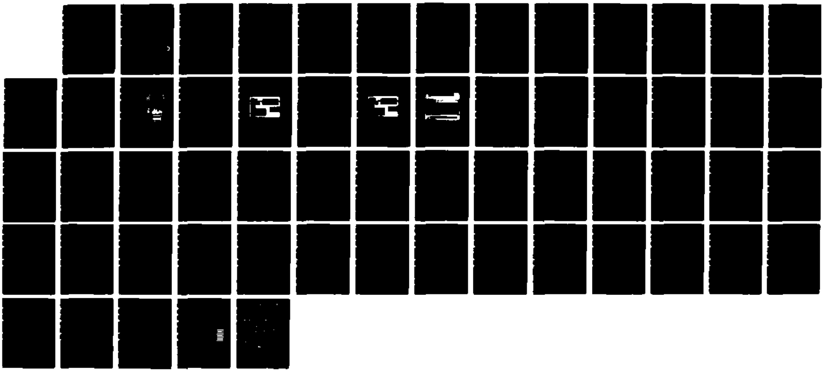
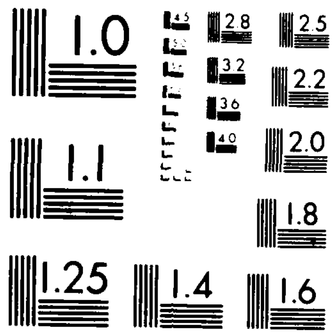
AD-A191 871 PERFORMANCE ESTIMATES FOR OPERATIONS CONDUCTED WHILE WEARING INDIVIDUAL P (U) ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD C H WICK JAN 88 BRL-MR-3647

1/1

UNCLASSIFIED F/G 23/4 NL




1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

AD-F 301 ...

AD

AD-A191 871

DTIC FILE COPY

MEMORANDUM REPORT BRL-MR-3647

PERFORMANCE ESTIMATES FOR OPERATIONS CONDUCTED WHILE WEARING INDIVIDUAL PROTECTIVE EQUIPMENT: USER MANUAL

CHARLES H. WICK

JANUARY 1988

DTIC
ELECTE
APR 25 1988
S D
H

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

88 4 25 004

DESTRUCTION NOTICE

Destroy this report when it is no longer needed. DO NOT return it to the originator.

Additional copies of this report may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The use of trade names or manufacturers' names in this report does not constitute indorsement of any commercial product.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

AD-A191871

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): MEMORANDUM REPORT BRL-MR-3647	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: U.S. Army Ballistic Research Laboratory; 6b. OFFICE SYMBOL (If applicable): SLCBR-VL-I	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): Aberdeen Proving Ground, MD 21005-5066	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. RDT&E; PROJECT NO. 1L162618; TASK NO. AH80; WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
PERFORMANCE ESTIMATES FOR OPERATIONS CONDUCTED WHILE WEARING INDIVIDUAL PROTECTIVE EQUIPMENT: USER MANUAL

12. PERSONAL AUTHOR(S)
Charles H. Wick

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
FINAL	FROM ____ TO ____		

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	MOPPIV; Force Structure; Degraded Effectiveness; Correction Factor; Individual Protective Equipment; Performance

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Methodologies are presented in the Performance DBase System for recalling a correction factor (CF) and its probable range for a soldier performing a task while wearing individual protective equipment (IPE) by task, human ability, or by a combination of both task and human ability. A model is given for making Force-on-Force estimations during CORPS operations conducted while wearing IPE using battalion sized units.

The CF is that factor which is used to multiply the time to complete a task while wearing the normal duty uniform to estimate the time to complete the same task while wearing IPE. By estimating this factor, the system gives the commander and his staff the methodology for making standardized estimates of the performance correction resulting from the wearing of IPE. The standardized procedures in obtaining the correction factor and in organizing the data allows the continuity among users and for a common basis for discussion of the effects of IPE on operations.

(Continued on reverse side)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: Charles H. Wick	22b. TELEPHONE (Include Area Code): 301-278-6339; 22c. OFFICE SYMBOL: SLCBR-VL-I

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

UNCLASSIFIED

Block 19. ABSTRACT (Continued):

The data base is expandable and as additional information becomes available and is processed, it can be included. This ability to accept performance data from a wide field of experience is especially important as data become available on extended operations including environmental factors. The system can then allow estimates to be made on future performance under severe conditions and thus avoiding the inherent dangers of expense of such exercises.

The Force-on-Force model allows for estimates to be made on the additional requirements on large operations conducted while wearing IPE. The model provides for priorities to be made based on proximity to the battle. By assigning priorities and battle codes, engaged in combat, combat imminent, not in combat, estimates can be made on force structure requirements for combat operations. These estimates are recommended for use by planners and staffs to estimate the effect of IPE during CORPS operations. The model can assess the "What if?" questions and estimate the effect that increased CFs, differences in priority, or battle codes may have on the force structure.

QUALITY INSPECTED 4

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes

Dist	Avail and/or Special
A-1	

UNCLASSIFIED

CONTENTS

LIST OF ILLUSTRATIONS

I. Introduction

1. General

The purpose of this publication is to describe the procedures which may be used to determine the individual performance decrement resulting from wearing individual protective equipment (IPE) for exercise and training purposes only. Further, it describes the procedure for using the Force-on-Force algorithm for predicting additional required battalion sized units for exercises simulating combat operations while wearing IPE.

Although actual operations are not explicitly described, it is believed that results using the Dbase and procedures of this publication will provide commanders and staff a realistic appreciation of the performance decrement which results from the wearing of IPE. The numerical results should be applied in training and exercise situations.

Section II is an introduction to the use of the Performance Dbase System. Section III is the methodologies which constitute the Dbase, the type of procedures used and the methodology for extracting information from the Dbase. Section IV introduces the user to the Force-on-Force algorithm and the hypothetical estimations for additional required battalion sized units during simulated combat operations while wearing IPE.

2. Background

Troop performance degradation resulting from the wearing of individual protective equipment (IPE) has been of increasing concern to commanders for some time. This IPE is worn in several configurations. The highest level of protection, in which all equipment is worn and sealed, is also the most bulky, cumbersome and restrictive. Personnel are protected at the expense of this encumbrance - a circumstance which results from impeded physiological functions such as vision, hearing, speaking, manual dexterity and others. This encumbrance produces degradation usually in the form of increased time to complete tasks, and in some cases, and reduced accuracy. For the purposes of this Performance Dbase, time to complete a task was the only factor used in determining personnel degradation resulting from the wearing of IPE.

Planning and simulations of combat in a chemical arena have been conducted over the last several years with one central question emerging time after time, "What is the impact on operations when soldiers are required to wear individual protective equipment?" The wearing of this equipment can influence the outcome of a battle by influencing command decisions regarding projected

force ratios and by generally creating additional confusion on an already complex battlefield. A knowledge of the impact that wearing IPE may have on the integrated battlefield could be the margin required for victory.

Attempts have been made to estimate the degradation which results from the wearing of IPE on several occasions. Results from early delphi studies were among the first attempts to estimate the impact of IPE on a variety of military operations. The limitations of these estimates were obvious when actual field studies were conducted to quantify the effect of wearing IPE. Field results generally demonstrated less decrement to soldiers resulting from the wearing of IPE than prior laboratory estimates. Several of these field trials were conducted to gather performance data in order to quantify the decrement resulting from the wearing of IPE. Detailed evaluations were made for task categories armor, maintenance, HAWK missile, and RATT operations while soldiers were wearing IPE. A night reconnaissance operation was also conducted to provide data on this type of performance. Field trials were conducted for two temperature ranges, the NATO hot and moderate. The resulting analysis of the data produced a correction factor (CF) for estimating performance decrement while wearing IPE. This factor is used to multiply the time required to complete a task while wearing the normal duty uniform to estimate the time required to complete the same task while wearing IPE.

The performance decrement is important to the individual soldier, crews and large units. The growing list of tasks completed while wearing IPE has added to the knowledge base required to predict operations conducted while wearing IPE. It is anticipated that future field trials will verify and add to this ability. It is important that any collection process utilize standardized methodologies and terms to provide all users with a common basis from which to compare their analyses.

II. **Performance Dbase System**

1. **Intorduction**

Presently, the Performance DBase System provides a methodology for recalling the correction factors and probable ranges for a number of tasks and the associated subtasks. A CF can be determined for various standardized human abilities and their associated subskills. The present system is expandiable and can form the basis for standardizing the recall and collection of this type of information.

Transforming the field data and the resulting analysis into a working Dbase system was the next step in standardizing the data for use. The analysis provided three methods for recalling the correction factors: first, by task; the second, by human

ability codes; and the third, by scenario. This last method allows the prediction of a CF from a combination of tasks and human ability codes. The Dbase represents a useful tool for the commander for estimating a CF for various tasks, human ability codes and scenarios.

Attempts to extrapolate the individual performance data to unit operations, and in particular to large unit operations, are not well-founded at this time, because of the many additional variables and complete absence of reliable data. Some data are available, and have been included for small crew operations. Building a complete data package to include operations of large field units is possible, and as these data become available the data base will be able to support estimates on the operations of larger units while wearing IPE. The averaging of multiple tasks performed by large groups, crews, teams and units is difficult without more data. Although field exercises are presently attempting to determine the CF for small units during field operations the data are not yet available. Eventually, results of such evaluations will lead to accurate estimates of large unit decrements resulting from the wearing of IPE, and the impact of wearing IPE on force structure questions at Corps and above will be answered. At this time, however, the default CF value of 1.5 is recommended for force structure questions, as this represents the total average correction factors for all the tasks in the current Dbase system.

2. Standardization

Commanders support the position that the wear and use of protective equipment in an NBC environment offers greater advantages than conducting operations in the same environment without the benefits of such equipment. Current plans call for the conduct of active combat missions on/over the NBC battlefield, and future battles are anticipated to require quick decisions on the part of the commander. To support decision making under such conditions, a directly readable and standardized performance decrement system is required. The Dbase will be maintained as a standardized source of information usable by all services when planning exercises under NBC conditions.

Standardized terms, data base structures, collection techniques and methods of analysis are important features of a standardized data base system. Therefore, all data should be collected using the same scenarios, techniques, and methodologies and future exercises or evaluations including and considering the data collection requirement set forth in this report.

III. Methodology

1. General

When field data are available these data should be used for estimating degradation due to the wearing of chemical protective equipment. Field trials have been completed with military personnel completing numerous military tasks while wearing both the duty uniform and IPE. Time to complete the task has been used as the measurement of degradation.

One of the more reliable methods for measuring performance decrement is to make a time/work analysis using a clock and task completion observations. By having personnel perform identical tasks while wearing the IPE and standard duty uniform the effect on performance due to the wearing of IPE can be determined and a correction factor calculated. Such a technique was used to collect the data for the Dbase system. The result is an accurate estimate of the correction factor for various operational tasks. As mentioned above, the Dbase contains tasks from Maintenance, HAWK, RATT, ARMOR and night reconnaissance operations. A complete task list is contained in Appendix A. Each major area has several separate tasks and each of tasks is sub-divided into several subtasks.

The process for calculating the regression values is given in Appendix B. This process separates the effect of wearing the IPE from the order of start or learning effect. As such, the CF determined is for the IPE only, other factors such as fatigue, lack of sleep and similar functions are not included at this time. The effects of factors can be added to the Dbase system once data are available.

2. System Design

The programming for operating the Performance DBase System allows the user to select from menus various options. Correction factors by task, human ability code and scenario can be selected. Access to the Force-on-Force model can be made, as well as help and other functions. The data base is designed to include various information on a task and the resulting analysis. A typical data base structure should include the task name, subtask name, correction factor, probable range information and indexes for task code and human ability codes. The data base can be sorted and processed based on the codes used. A typical data base structure is given in Figure 1, which includes an example input. Figure 2 illustrates the relationship between menus in the program.

Typical Data Base Structure

Task: Maintenance

Subtask: Power Pack M60A3

Correction Factor: 1.5

Range Low: 1.3

Range High: 2.1

Task Code: MO

Subtask Code: PP M60A3

Human Ability Code: MCS

Human Ability Sub-code: GBM

Figure 1. Typical data base structure for organizing information. The maintenance example includes the subtask, power pack. Codes are used for indexing the data base to sort on particular records, the codes used are: MO, maintenance operations; PPM60A3, M60A3 power pack; MCS, manual control skills; GBO, gross body coordination.

3. **Using the Program Disk**

The program disk, labeled "Performance Dbase System, Version 1.0, October 1987," contains four files, two are system files which allow the disk to be self booting. Of the other two files, one is the executable file named IPE.EXE and the other is the data base file named MOPP.DBF. To access the program, install the program disk in drive A of an IBM or compatible computer and turn it on. The program will load itself and present the user with the main menu Figure 3.

4. **Examples**

a. **Performance Correction Factor by Task.** Among the options on the main menu is the selection of correction factors by task. After selecting this option, a new menu is presented (Figure 4). This menu presents the various tasks available for selection. From this list of task types, for example: maintenance, armor, HAWK, RATT, or night reconnaissance, a selection is made.

Selecting a task type, such as Maintenance, results in the display of the correction factor, probable range and list of subtasks. For example, when maintenance is selected all CFs for maintenance tasks are averaged in the MOPP.DBF and the result displayed, including the probable range (Figure 5). Sub-tasks may be selected from a listing. The display process is repeated as above for the sub-task. For example, selection of the M60A3 power pack would result in the display of a correction factor for all the subtasks in this category and the probable range (Figure 6). Additional sub-tasks are listed for the M60A3 power pack. In this manner, a task such as removing the accessories from the power pack removal of a M60A3 tank can be selected and the appropriate CF and probable range displayed.

b. **Performance Correction Factor by Human Ability.** A similar process is repeated for selecting a CF based on human abilities. From the main menu the CF by human ability is selected. The user is presented with a list of human abilities in a menu (Figure 7). The user selects an appropriate human ability resulting in a display similar to "tasks" with the exception that the CF and probable range are for each human ability code, for example communications (Figure 8). The CF is determined by making an average for all tasks identified with the appropriate code. Since some tasks are associated with more than one code it may be accessed from different selections. A complete list and definitions of the human abilities are given given in Appendix C.

The relationship between human factor code and task data is as follows. Each task has a known CF based on field experience. It is assumed that the CF is the same for the task even if it is identified not by a task name but by functional area, or human ability. Thus a CF for gross body coordination skill is

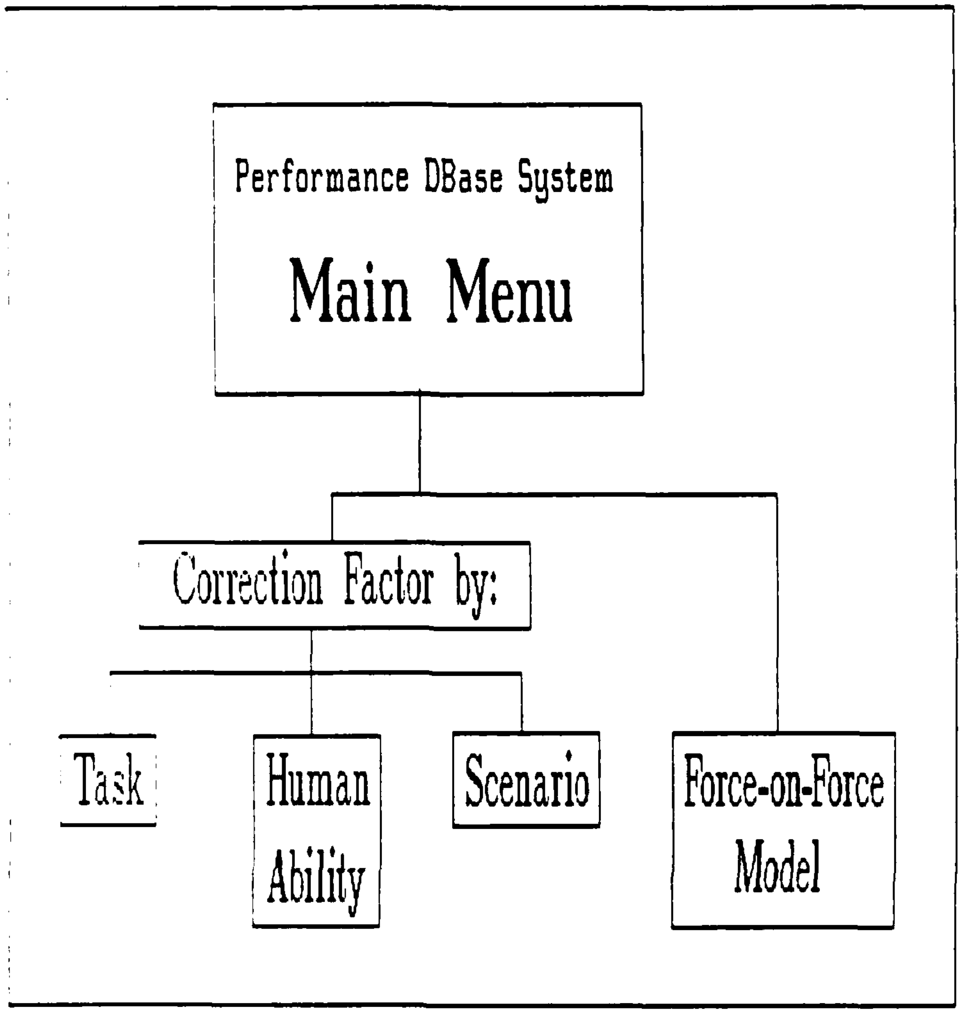


Figure 2. Block diagram of menu selections. Correction factor is that value which when multiplied by the time to complete a task while wearing the normal duty uniform to estimate the time to complete a task while wearing individual protective equipment.

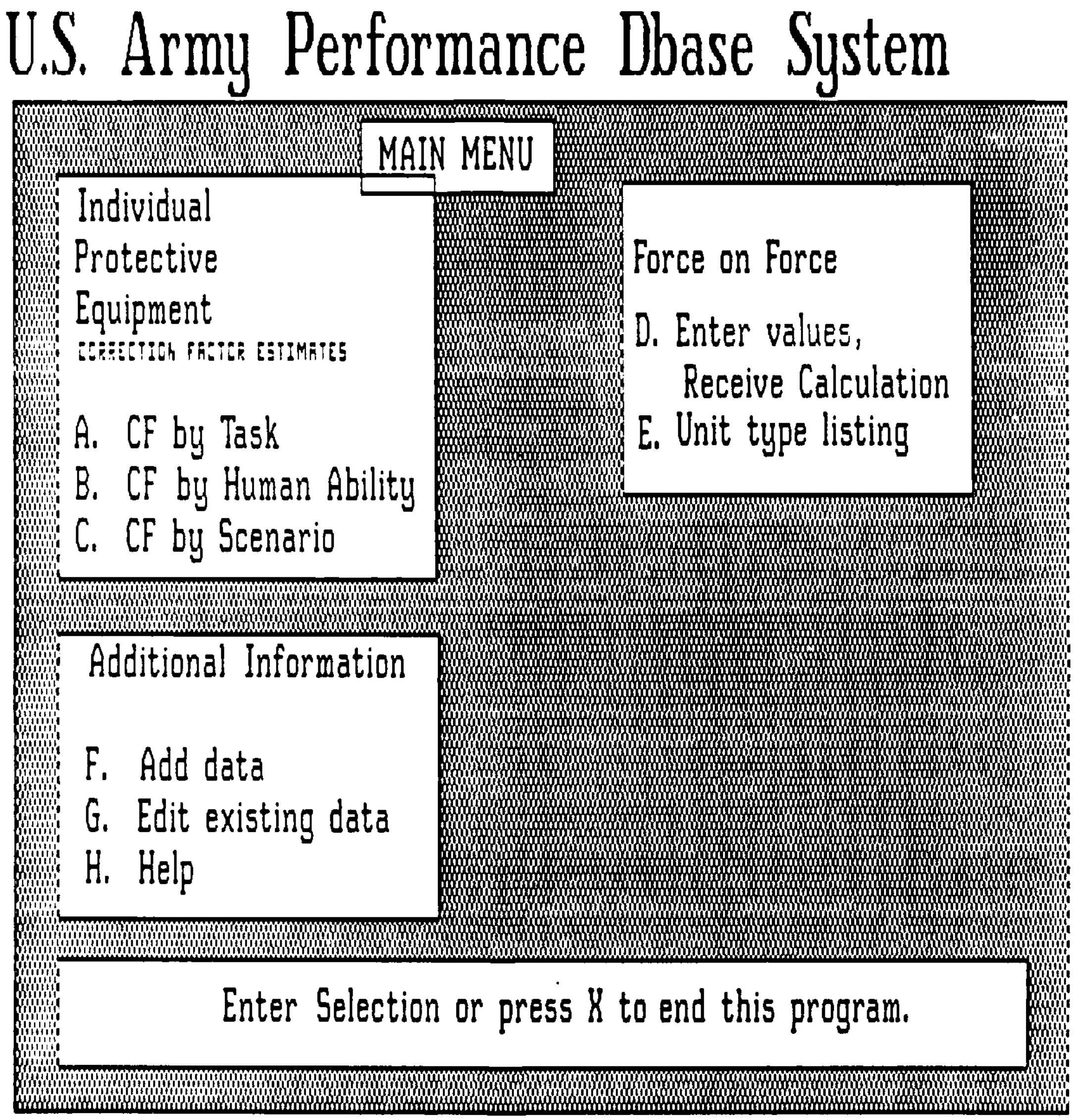


Figure 3. Main menu for USA Performance Dbase system and Force on Force Algorithum. Selection is made for activation of indicated programs.

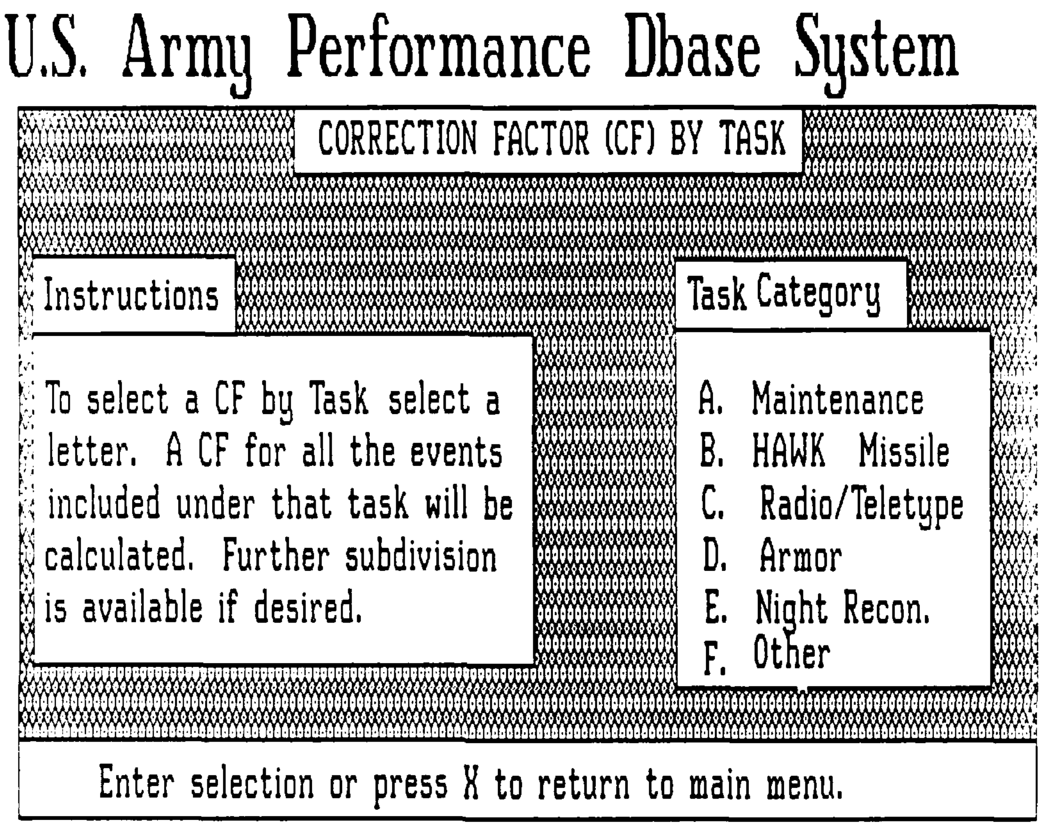


Figure 4. Menu for selection of tasks for determination of correction factors (CF) for soldiers wearing individual protective equipment.

U.S. Army Performance Dbase System

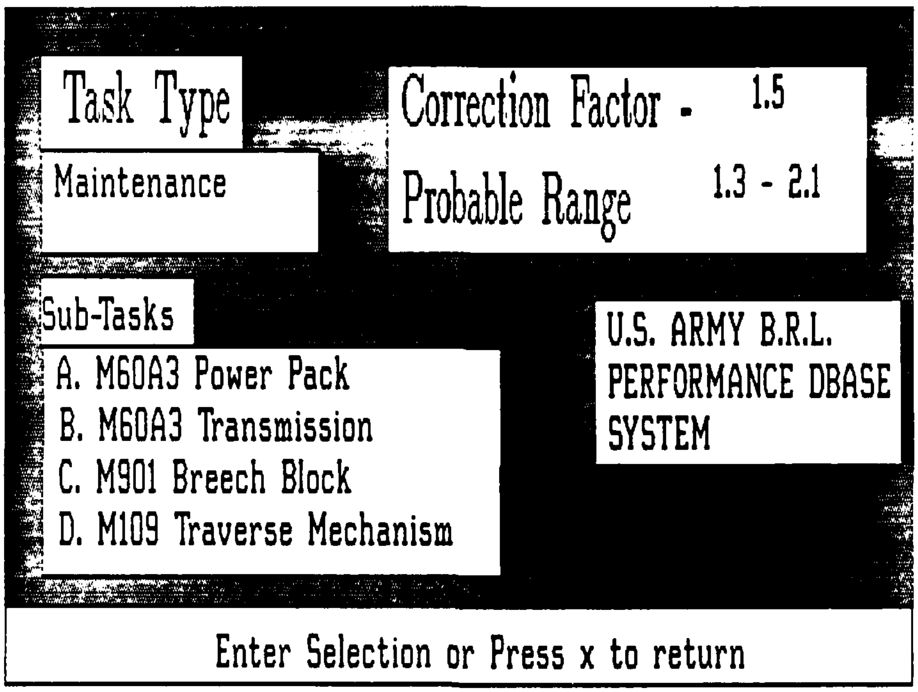


Figure 5. Correction factor (CF) for maintenance tasks. Note probable range and subtasks which are available for further investigation.

equivenlent to the CF obtained for the task "remove the power pack of a M60A3 Tank." By making this assumption a combination of human factors can be used to make estimates of the CFs for tasks where no title has been identified.

c. **Performance Correction Factor by Scenario.** Selection of a CF by scenario is a combination of both the task and human ability procedures. The difference is that the initial selections are stored for processing with additional entries. A scenario is a selection of tasks or human abilities which make up an event. For example, replacing the transmission on a tank is made up of several subtasks which can be identified by name or human ability area. To determine the CF all the tasks are processed together to yield a CF. The method used for determining the CF for the task is to first determine the CF for each subtask, second, estimate the time for each subtask or the percent of the total time for each subtask (the program will make the necessary conversion and display the percent of each subtask), and third make the calculation for the CF. The subtasks are weighted since it is not realistic to weight each component equally. This prevents a short duration component having a high CF from excessive influence on the average of the total CF.

CF by scenario is selected from the main menu. The user is prompted for input by task or by human ability. The same selection screens appear as for tasks or human abilities. The difference is that the answer is then saved and the user is queried for another selection. The process is repeated until the user has selected all the inputs desired and selects no further entries. At this time the program calculates the CF and probable range for the scenario based on the corresponding data in the Dbase. Suppose that a scenario is composed of a human ability, a task, and another human ability. The scenario is then: finger dexterity, 10 minutes; maintenance, 20 minutes; and gross body coordination 30 minutes. The process is then to first select the human ability list and choose the finger dexterity entry, then return to the main menu and select maintenance, and finally, return to the human ability list and select gross body coordination. The time required for each subtask is entered for each selection. After indicating that no further entries are required the program will then calculate the corresponding CF and probable range (Figure 9).

5. Discussion

Correction factors can be determined from the Dbase system by either task, human ability code or by scenario. This last method, scenario, combines the correction factors for the several subtasks of a complex task. This flexibility allows an analyst or staff member to make valuable estimations concerning the performance of a wide range of tasks to be performed while wearing IPE. It should be noted that the estimates based on individual tasks are the most accurate estimates, since these are based on

U.S. Army Performance Dbase System

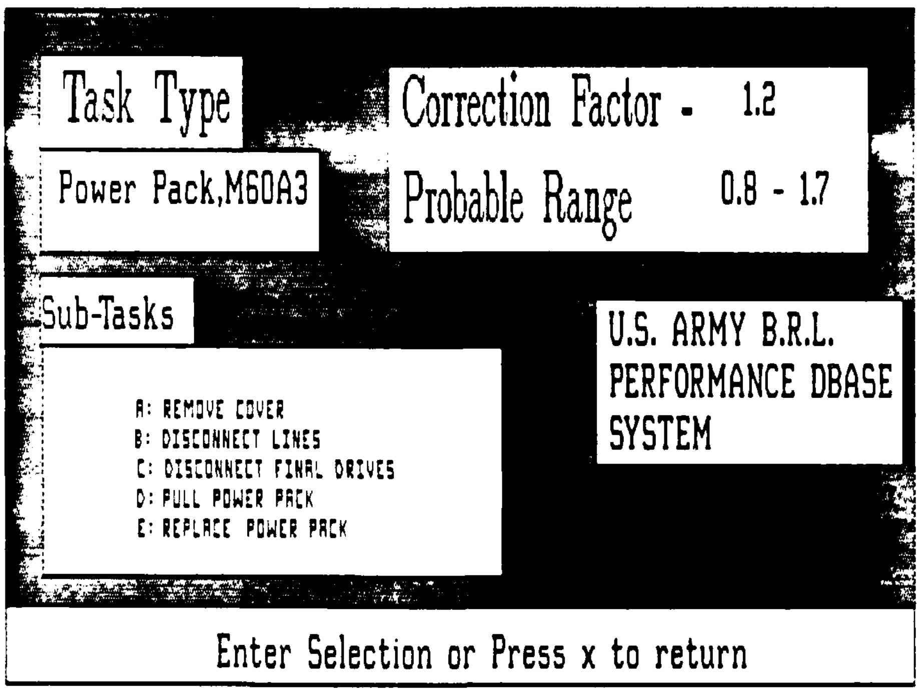


Figure 6. Correction factor (CF) for removing and replacing the M60A3 Power Pack.

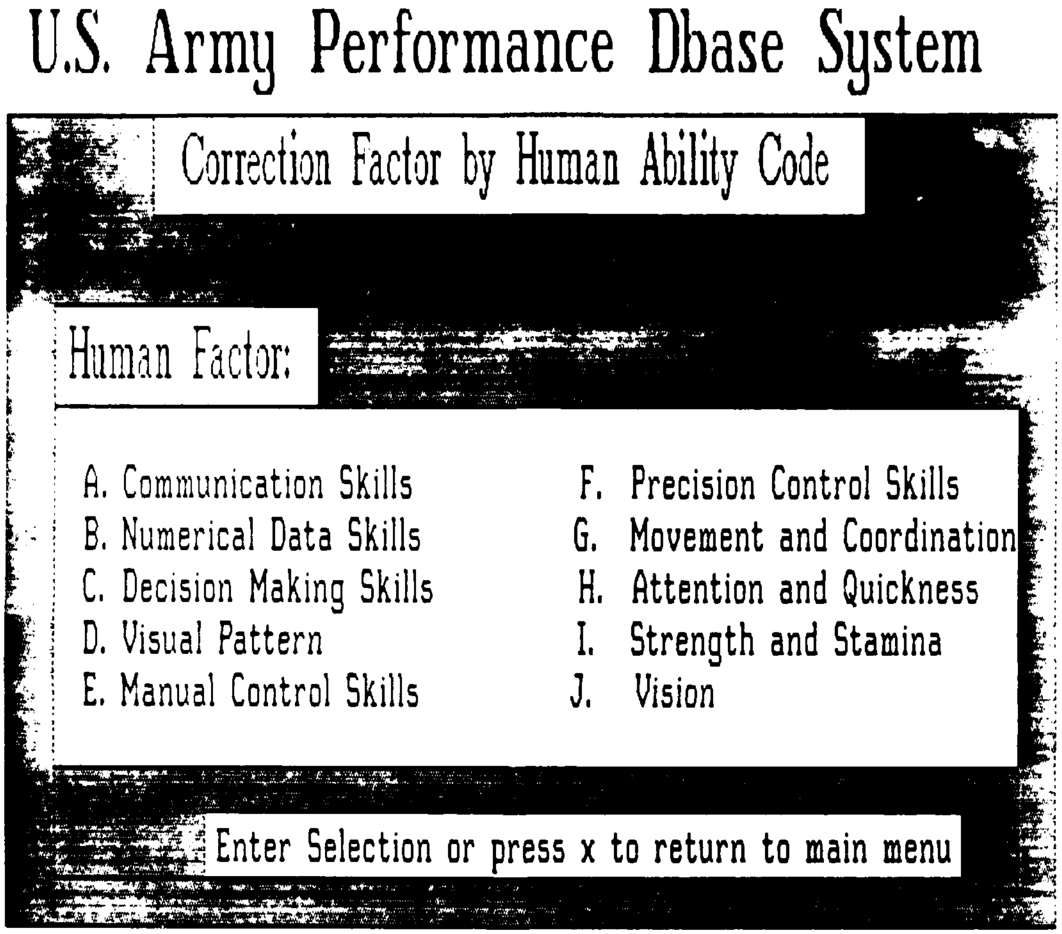


Figure 7. Menu for Selecting Correction Factor by Human Ability Code.

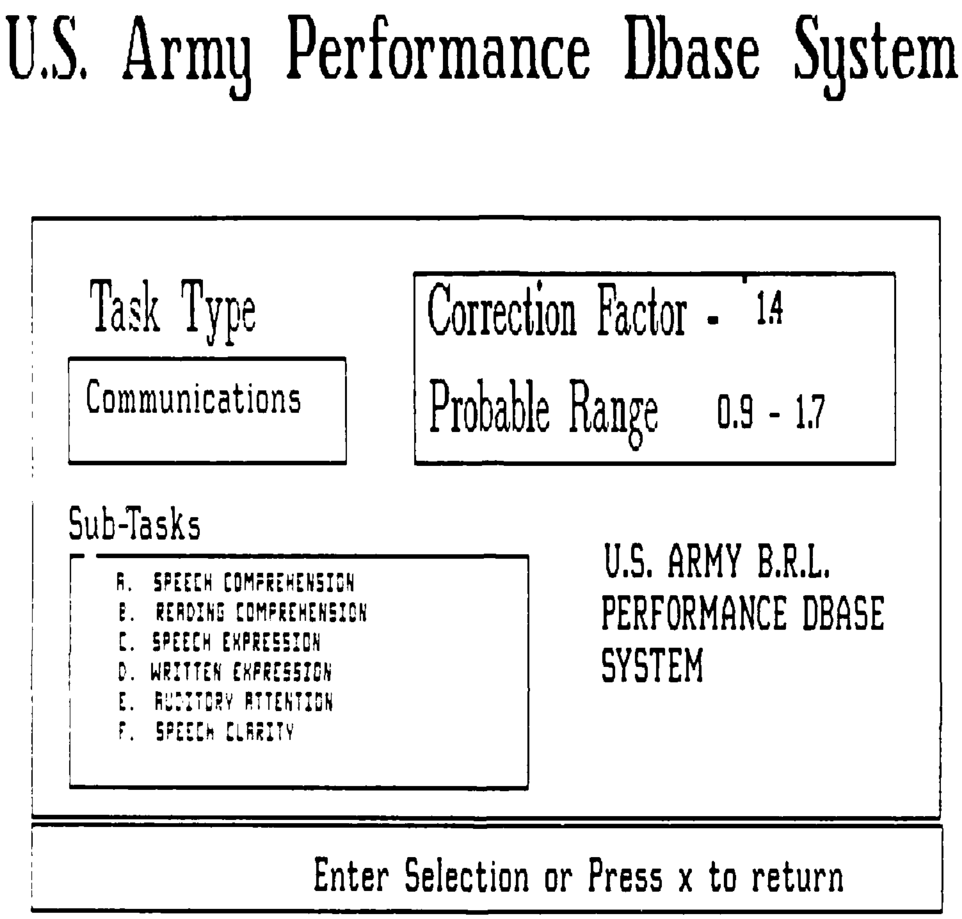


Figure 8. Example of correction factor (CF) calculation for a human ability code, communications. Notice the available sub-tasks for further investigation.

U.S. Army Performance Dbase System

CORRECTION FACTOR BY SCENARIO

COMPONENT	% TOTAL	CF	PROBABLE RANGE
1. Finger Dexterity	17	2.0	1.5 - 2.4
2. Maintenance	33	1.5	1.3 - 2.1
3. Gross Body Coord.	50	1.2	1.0 - 1.4
Total	100	1.5	1.2 - 2.0

Enter Selection or Press x to return to main menu

Figure 9. Correction factor by scenario, a combination of task and human ability codes. Notice that the total CF is 1.5 which is less than the average which is 1.6 since the total components of the task are weighted according to their contribution to the whole task.

the actual completion of the same tasks in the field by multiple personnel. Estimates based on human ability code are an extrapolation of the performance data as broken into standardized human ability terminology. Thus the correction factor by human ability represents a mixture of tasks. Likewise, the estimates of a correction factor for a scenario composed of various human ability codes is an estimate based on multiple tasks combined in a function manner to yield a correction factor. The correction factor for the scenario does not presently contain a function for any synergistic effects between scenario tasks.

Correction factors are best estimated for actual tasks which have been completed by soldiers in the field. Data generally represents tasks which were timed or measured and do not represent tasks which use a different measure of effectiveness. For example, the Dbase contains quantified CFs for removing or replacing several items of equipment on the M60A3 tank, but does not contain CFs for the M60A3 making an attack. "Attack", "defend", and "move to the FEBA" are jobs which are more difficult to evaluate. The CF for these types of tasks can be roughly inferred from their components, but nevertheless there is no substitute for the tasks having been accomplished under particular conditions with a quantifiable measurement of task completion.

The Dbase is expandable. As information is obtained for additional tasks, these data can be appended. Equally important is the ability to add a different type of information to the Dbase. As information becomes available on extended operations over wide ranges of environmental conditions these data can likewise be added. The Dbase system can accommodate individual, crew, small unit and eventually large unit performance data, but the information needed from field exercises must be as complete as possible to be useful in this Dbase. The information required is listed in Appendix D.

A discussion of performance decrement would not be complete without a comment on the prediction of large unit operations. For this discussion "large unit" will be confined to battalion (BN) or equivalent sized units. This size unit represents a standard building block of divisions and is used to make task force and other special configurations for battle. Without actual field data collected under particular conditions where the data represent unit operations under a standard scenario, it is difficult to extrapolate the unit decrement resulting from the wearing of IPE from individual decrement data. Analysts frequently are asked to make predictions on large unit operations. Among these is a frequent request for the number of additional battalions needed because operations are being conducted on a chemical battlefield. This question is related to the Performance Dbase System only in that when data are available can this question be asked and displayed for size of unit, type of operation, duration of operation and environmental conditions. Until this type of detailed data is acquired and analyzed the Force-On-Force

algorithm given in Section IV is recommended.

IV. FORCE STRUCTURE ALGORITHM

1. Introduction

In addition to the individual performance decrement resulting from the wearing of IPE, a measurement of unit performance decrement as the result of wearing IPE is desired. Staff actions regarding force structure requirements as modified by the need to wear IPE have prompted the creation of a force structure algorithm. The unit size is a battalion. The effect of wearing IPE on force structure can be estimated for combat, combat support and combat service support battalions by assigning an estimation of the combat value of a particular battalion and its average CF at a given moment in a combat scenario. An estimate of the number of additional battalions, by type, can be made.

2. Methodology

The number of additional battalions required is determined by first assigning values to the battle code (BC), priority and correction factor inputs then making a the following calculation:

$$((CF*FSndx / FScode) * \#BNs) - \#BNs$$

where CF is the correction factor, FSndx is the force structure index determined from the battle code and priority inputs, FScode is the highest value assigned to FSndx and #BN is the number of battalions in question. The answer is the projected number of battalions required.

By assigning a value to battle code and priority, a value is assigned to FSndx. FSndx has different values for combat, combat support and combat service support type units and is related according to the following matrix (Figure 10). The battle codes are self explanatory and represented by 1. Attack, 2. Defend, and 3. Other Duties. The priority codes, however, are interpreted as follows: Priority 1, directly involved in combat; priority 2, combat imminent; priority 3, awaiting combat. Since the primary mission of infantry, armor and artillery is combat each class would receive the highest force structure code (FScode) for this action. Combat support and combat service support units are generally not directly involved in combat, and thus receive a lower FScode. This is not minimizing their value in this combat-weighted calculation. Other scenarios could modify these values to make other estimations. Defaults of 1 are entered for BC and Priority, High Black (HB) for Level, and 10 for the number of BNs.

U.S. Army Force on Force Algorithum

MATRIX FOR FORCE STRUCTURE INDEX

BATTLE CODE

	PRIORITY	Attack	Defend	Other
INFANTRY	1	5	5	3
	2	4	4	3
	3	3	2	1
ARMOR	1	5	5	3
	2	4	4	3
	3	3	3	3
ARTILLERY	1	5	5	3
	2	4	4	2
	3	4	4	1
CBT. SUPPORT	1	4	4	4
	2	3	3	3
	3	2	2	2
CBT. SEV. SPT	1	3	3	3
	2	2	2	2
	3	1	1	1

FIGURE 10. BATTLE CODE AND PRIORITY MATIRX FOR DETERMINING FORCE STRUCTURE INDEX FSndx.

The process for making a force structure estimate is to first select the FS option from the main menu. The user will then be presented with a screen having the three combat arms, combat support, and combat service support elements on one side with inputs requested for battle code, priority, protection level, and number of BNs. Inputs are made for medium (M), high (H) and high black (HB) protection levels. If required a numerical CF can be entered. A default CF of 1.5 is used as a guide. Since actual data are not currently available for estimating BN performance while wearing IPE, this should only be used as an estimate. The number of BNs representing this situation is then input and the calculation is automatically displayed under "Additional BNs Required." Inputs are repeated for the various combat, combat support, and combat service support lines.

After initial procedures, values are input for BC, Priority, Protection Level and number of BNs. Battle Code and Priority range from 1-3. Protection level can either be a number or the code for medium, high or high black. In this example, correction factors are entered as numbers. Estimates are calculated for any inputs. An example is given in Figure 11. Notice that results vary among the required battalions even though entries are the same.

3. **Discussion**

The Force on Force calculation is recommended for use by planners and staffs to estimate the effect of IPE on BN sized units. The BN is the planning block for force replacement problems, logistics and tactical planning. Since a BN is used in this manner, it is appropriate to make estimates on its performance when operating in IPE. Since no clear data are available on this function, and remembering that there are many different kinds of BNs in a CORPS, and that it will be difficult to acquire this information in the near future, the use of a model is germane.

Initially, the Force on Force model can be used to make estimates of the number of additional forces required in a given battle situation. Two main values of this estimation are: first, that the number of additional forces will generally be less than if a single degradation value without a priority system were used. That is, if a CF of 2.0 were used across the battlefield, the commander would require twice as many BNs to complete the mission. Using this estimator, the commander would require fewer BNs to accomplish the same mission, simply because all the units on the battlefield do not have the same importance at any given moment, even units of the same generic type. These units will be conducting various operations: some are in combat; others are awaiting combat; and many more are moving, resting or otherwise doing tasks not actually associated with immediate combat. Thus, units are weighted according to the moment's needs of the battle and the commander. Second, inputs to the model can be modified

U.S. Army Force-on-Force Algorithum

Example inputs and calculations

UNIT TYPE	BATTLE CODE	PRIORITY	CF	#BN	ADDITIONAL REQUIRED
INFANTRY	1	1	1.5	10	5.0
ARMOR	1	1	2.0	10	10.0
ARTILLERY	1	2	1.5	10	2.0
COMBAT SUPPORT	1	1	1.5	10	2.0
CBT SERVICE SPT	1	1	2.0	10	2.0

BATTLE CODE = 1-3 PRIORITY = 1-3

Enter any key to continue, and x to return to main menu.

Figure 11. Force-on-Force example with sample inputs and calculations.

to assess "what if ?" questions, and to estimate the effect increased CFs, differences in priority, or the battle code itself may have. As such, the model adds to the planning and estimation techniques available to the commander and his staff for making force on force estimations for operations in a chemical arena.

V. Summary

1. Performance Dbase System

The performance Dbase system gives a commander and his staff the methodology to determine a correction factor (CF) for individual tasks completed while wearing individual protective equipment (IPE.) The Dbase also provides for estimates to be made regarding performance decrements on the basis of human ability terminologies and a combination of terms and tasks. This ability to estimate allows for the estimation of a CF for new tasks. Thus, the commander and his staff can estimate the effect of wearing IPE may have on jobs and missions created only for planning and training purposes. The standardized terminology and methodologies for collecting and processing the data in the Dbase system allows for continuity among users and allows for a common basis for discussing the effects of IPE on operations.

Additional data can be added to the present Dbase system. As individual performance data become available in the standardized format it should be processed and added to this Dbase. Likewise, the information collected on extended operations in IPE can be processed and added. This is especially important since the concept of continuous operations is inherent in present doctrine. The expansion of the Dbase can include environmental conditions, such as temperature, relative humidity, and solar load. Thus, the process can include performance decrements resulting from extended operations at various temperatures and relative humidities. Estimates of the impact on future performance under severe conditions can thus be evaluated without the inherent dangers or expense of such exercises.

2. Force on Force Algorithm

The prediction of the force ratio is important in making the decision to attack, defend or disengage from the enemy. The Battalion is the common building block for making these ratio decisions and, as such, is the size of unit about which the question of the effects of IPE are most often asked. This model presents a methodology for making this estimation for Combat (Infantry, Armor, Artillery), Combat Support (Engineers, Chemical) and Combat Service Support Units (Medical, Finance, Transportation, and other units). The methodology includes providing a priority index for units on the battlefield according to their immediate contribution to the battle. For example, a combat unit in action has a greater priority than a combat unit resting or being

reconstructed. This methodology allows for an estimate of the effect of IPE on operations according to this prioritization. Units with a low priority are considered to have sufficient time to complete a task even though they are degraded by the wearing of IPE. The estimation can thus provide appropriate force ratios for the commander to make decisions regarding the capability of the force.

Data from large unit operations while wearing IPE can be processed and added to the Dbase system presented in Section I, which would allow estimations of performance while wearing IPE for larger units, eventually including battalions. The value of adding these performance data to this system is to allow the generic type battalions to establish their own force structure indexes (FSndx) and their own priority system to the battle. The present model should be used for planning and training to make estimates of the effect of IPE. As data from field operations while wearing IPE become available, a war manual can be prepared with actual priorities and battle codes.

The program disk can be obtained by following the procedure in Appendix E.

APPENDIX A

Dbase Listing by Task, Correction Factor, and Probable Range

Performance Dbase System - Task Listing

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland

Task	Sub-Task	Correction Factor (CF)	Probable Range	
CONTINUOUS AQUISITION WAVE RAD	EMPLACE CWAR	1.30	1.20	1.50
CONTINUOUS AQUISITION WAVE RAD	GROUND CWAR	1.20	1.10	1.20
CONTINUOUS AQUISITION WAVE RAD	LEVEL CWAR	1.20	0.90	1.50
CONTINUOUS AQUISITION WAVE RAD	ENERGIZE CWAR	1.00	1.00	1.10
CONTINUOUS AQUISITION WAVE RAD	PERFORM DAILYS	1.40	1.20	1.50
CONTINUOUS AQUISITION WAVE RAD	ALIGN CWAR	1.20	0.70	1.60
CONTINUOUS AQUISITION WAVE RAD	MARCH ORDER CWAR	1.10	1.00	1.20
CONTINUOUS AQUISITION WAVE RAD	SECURE ANT. COVER	1.00	0.90	1.10
CONTINUOUS AQUISITION WAVE RAD	SECURE CABLES	1.00	0.90	1.10
CONTINUOUS AQUISITION WAVE RAD	EMPLACE CWAR	1.40	1.30	1.50
CONTINUOUS AQUISITION WAVE RAD	LEVEL CWAR	1.40	1.30	1.50
CONTINUOUS AQUISITION WAVE RAD	ENERGIZE CWAR	1.60	1.40	1.70
CONTINUOUS AQUISITION WAVE RAD	PERFORM DAILYS	2.00	1.20	2.90
CONTINUOUS AQUISITION WAVE RAD	ALIGN CWAR	1.90	1.60	2.20
CONTINUOUS AQUISITION WAVE RAD	MARCH ORDER CWAR	1.40	1.30	1.60
CONTINUOUS AQUISITION WAVE RAD	SECURE ANT. COVER	1.70	1.30	2.10
CONTINUOUS AQUISITION WAVE RAD	SECURE CABLES	1.50	1.30	1.60
FADAC Printed Circuit Board	REMOVE PROTECTIVE COATING	1.30	1.10	1.60
FADAC Printed Circuit Board	REMOVE RESISTOR	1.50	1.00	1.90
FADAC Printed Circuit Board	REMOVE TRANSISTOR	1.90	1.20	2.70

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland

Task	Sub-Task	Correction Factor (CF)	Probable Range	
FADAC Printed Circuit Board	REPLACE RESISTOR	1.70	1.30	2.10
FADAC Printed Circuit Board	REPLACE TRANSISTOR	1.90	1.50	2.40
HIGH POWER	EMPLACE HIPIR	1.50	1.20	1.70
HIGH POWER ILLUMINATOR RADAR	STOW ANT. COVERS	1.50	1.20	1.80
HIGH POWER ILLUMINATOR RADAR	LEVEL HIPIR	1.30	1.10	1.40
HIGH POWER ILLUMINATOR RADAR	ALIGN HIPIR	2.80	2.10	3.50
HIGH POWER ILLUMINATOR RADAR	PERFORM DAILYS	2.10	1.50	2.70
HIGH POWER ILLUMINATOR RADAR	MARCH ORDER HIPIR	1.60	1.50	1.70
HIGH POWER ILLUMINATOR RADAR	STOW ANT.	2.10	1.40	2.80
HIGH POWER ILLUMINATOR RADAR	SECURE VENT COVERS	2.20	1.60	2.80
HIGH POWER ILLUMINATOR RADAR	EMPLACE HIPIR	1.50	1.40	1.50
HIGH POWER ILLUMINATOR RADAR	STOW ANT. COVERS	1.50	1.00	2.00
HIGH POWER ILLUMINATOR RADAR	LEVEL HIPIR	1.60	1.40	1.90
HIGH POWER ILLUMINATOR RADAR	ALIGN HIPIR	1.50	1.30	1.80
HIGH POWER ILLUMINATOR RADAR	PERFORM DAILYS	1.10	1.10	1.20
HIGH POWER ILLUMINATOR RADAR	MARCH ORDER HIPIR	1.30	1.20	1.40
HIGH POWER ILLUMINATOR RADAR	STOW ANT.	1.20	1.10	1.30
HIGH POWER ILLUMINATOR RADAR	SECURE VENT COVERS	1.20	1.10	1.30
LAUNCHER/LOADER	EMPLACE LCHR	1.40	1.30	1.50
LAUNCHER/LOADER	LEVEL LCHR	1.10	0.70	1.50
LAUNCHER/LOADER	UNLOAD MISSLE FROM PALLET	1.00	0.90	1.20
LAUNCHER/LOADER	ALIGN LCHR	1.60	1.40	1.80

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland

Task	Sub-Task	Correction Factor (CF)	Probable Range	
LAUNCHER/LOADER	LOAD MISSLE ONTO LCHR	0.90	0.80	1.00
LAUNCHER/LOADER	PERFORM SATO CHECKS	0.90	0.80	1.10
LAUNCHER/LOADER	ARM MISSLE	0.70	0.40	1.00
LAUNCHER/LOADER	UNLOAD MISSLE FROM LCHR	1.30	1.20	1.40
LAUNCHER/LOADER	MARCH ORDER LCHR	1.30	1.20	1.50
LAUNCHER/LOADER	RM&STOW STAKES	0.80	0.70	1.00
LAUNCHER/LOADER	EMPLACE LCHR	1.20	1.00	1.40
LAUNCHER/LOADER	LEVEL LCHR	1.20	1.00	1.40
LAUNCHER/LOADER	UNLOAD MISSLE FROM PALLET	1.20	1.10	1.40
LAUNCHER/LOADER	ALIGN LCHR	2.10	1.50	2.70
LAUNCHER/LOADER	PRELOAD CHECKS	1.50	1.00	1.90
LAUNCHER/LOADER	TRANSFER MISSLE ONTO LCHR	0.80	0.70	1.00
LAUNCHER/LOADER	LOCK MISSLE TO LCHR	2.10	1.10	3.10
LAUNCHER/LOADER	PERFORM SATO CHECKS	1.20	0.90	1.50
LAUNCHER/LOADER	ARM MISSLE	1.00	0.90	1.10
LAUNCHER/LOADER	POSITION LCHR FOR BOOM UNLOADI	1.60	1.10	2.00
LAUNCHER/LOADER	TRANSFER MISSLE TO PALLET	1.00	0.90	1.20
LAUNCHER/LOADER	MARCH ORDER LCHR	1.20	1.10	1.40
M109 BREECH BLOCK	REMOVE DAMPER	1.50	1.30	1.80
M109 BREECH BLOCK	REMOVE FIRING MECHANISM	1.10	0.70	1.40
M109 BREECH BLOCK	REMOVE BREECH BLOCK	1.50	0.80	2.10
M109 BREECH BLOCK	REPLACE SPINDLE	1.30	0.90	2.50
M109 BREECH BLOCK	REPLACE BREECH	2.80	2.00	3.80
M109 BREECH BLOCK	REPLACE FIRING MECHANISM/DAMPE	1.20	1.00	1.40
NIGHT RECON	REPEL INTO LANDING ZONE	2.00	0.90	3.10

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland, USA

Task	Sub-Task	Correction Factor (CF)	Probable Range	
NIGHT RECON	ASSEMBLE AT RALLY POINT	1.00	0.60	1.30
NIGHT RECON	MOVE TO 1ST OBJECTIVE	3.40	3.00	3.70
NIGHT RECON	MOVE TO 2ND OBJECTIVE	1.50	1.00	2.00
NIGHT RECON	EVALUATORS OBSTACLE	2.10	1.20	3.10
NIGHT RECON	REPORT ON VEHICLE	0.80	0.50	1.10
NIGHT RECON	MAKE HASTY SKETCH	2.10	1.50	2.70
NIGHT RECON	MOVE TO EXTRACT POINT	1.50	1.30	1.70
NIGHT RECON	REPEL INTO LANDING ZONE	3.10	2.10	4.20
NIGHT RECON	ASSEMBLE AT RALLY POINT	1.60	1.00	2.10
NIGHT RECON	MOVE TO 1ST OBJECTIVE	1.20	1.20	2.20
NIGHT RECON	MAKE HASTY SKETCH	0.90	0.80	1.00
NIGHT RECON	EVALUATORS OBSTACLE	1.40	0.80	1.80
NIGHT RECON	IMPLACE DEMOLITONS	0.90	0.70	1.20
NIGHT RECON	DESTROY TOWER	0.70	0.50	0.90
NIGHT RECON	MOVE TO EXTRACT POINT	1.20	0.60	1.80
NIGHT RECON	REPEL INTO LANDING ZONE	2.20	1.20	3.20
NIGHT RECON	ASSEMBLE AT RALLY POINT	0.80	0.60	1.10
NIGHT RECON	MOVE TO 1ST OBJECTIVE	2.20	0.90	3.50
NIGHT RECON	MOVE TO 2ND OBJECTIVE	3.20	2.40	4.00
NIGHT RECON	EVALUATORS OBSTACLE	1.00	0.80	1.30
NIGHT RECON	DESTROY COMM STATION	0.80	0.60	1.10
NIGHT RECON	MOVE TO EXTRACT POINT	1.10	1.00	1.10

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland, USA

Task	Sub-Task	Correction Factor (CF)	Probable Range	
PLATOON COMMAND POST	EMPLACE PCP	0.90	0.90	1.00
PLATOON COMMAND POST	GROUND PCP	0.90	0.80	1.10
PLATOON COMMAND POST	LAY CABLES	0.80	0.70	0.80
PLATOON COMMAND POST	EMPLACE IFF	1.30	1.20	1.40
PLATOON COMMAND POST	ALIGN IFF TO BASE UNIT	0.90	0.70	1.20
PLATOON COMMAND POST	PERFORM TDECC	1.40	1.20	1.60
PLATOON COMMAND POST	PERFORM DAILY IFF CHECKS	1.40	1.30	1.50
PLATOON COMMAND POST	MARCH ORDER PCP	1.30	1.20	1.40
PLATOON COMMAND POST	STOW IFF	1.30	1.30	1.40
PLATOON COMMAND POST	SECURE CABLES	0.70	0.60	0.90
PLATOON COMMAND POST	EMPLACE PCP	1.30	1.10	1.40
PLATOON COMMAND POST	GROUND PCP	2.30	1.60	3.00
PLATOON COMMAND POST	LAY CABLES	1.80	1.50	2.00
PLATOON COMMAND POST	EMPLACE IFF	0.80	0.60	1.10
PLATOON COMMAND POST	ALIGN IFF TO BASE UNIT	1.50	1.20	1.90
PLATOON COMMAND POST	PERFORM DAILY CHECKS	1.70	1.30	2.00
PLATOON COMMAND POST	PERFORM DAILY IFF CHECKS	1.70	1.10	2.40
PLATOON COMMAND POST	MARCH ORDER PCP	1.30	1.20	1.50
PLATOON COMMAND POST	STOW IFF	1.30	1.10	1.40
PLATOON COMMAND POST	SECURE	1.40	1.20	1.60
PLATOON COMMAND POST	EMPLACE PCP	1.30	1.10	1.40
PLATOON COMMAND POST	GROUND PCP	2.30	1.60	3.00
PLATOON COMMAND POST	LAY CABLES	1.80	1.50	2.00
PLATOON COMMAND POST	EMPLACE IFF	0.80	0.60	1.10
PLATOON COMMAND POST	ALIGN IFF TO BASE UNIT	1.50	1.20	1.90
PLATOON COMMAND POST	PERFORM DAILY CHECKS	1.70	1.30	2.00
PLATOON COMMAND POST	PERFORM DAILY IFF CHECKS	1.70	1.10	2.40
PLATOON COMMAND POST	MARCH ORDER PCP	1.30	1.20	1.50
PLATOON COMMAND POST	STOW IFF	1.30	1.10	1.40
PLATOON COMMAND POST	SECURE	1.40	1.20	1.60
POWER PACK	COVER	1.10	0.60	1.70
POWER PACK	TURRET CONNECTIONS	1.10	0.70	1.50
POWER PACK	ACCESSORY CONNECTIONS	1.50	1.00	2.00

POWER PACK	REMOVE POWER PACK	1.30	1.00	1.50
POWER PACK	REPLACE DECK	1.10	0.80	1.30
POWER PACK	REPLACE ENGINE AND ACCESSORIES	2.70	1.80	3.60
PULSE AQUISITION RADAR	EMPLACE PAR	1.40	1.20	1.60
PULSE AQUISITION RADAR	LEVEL PAR	2.20	1.80	2.60
PULSE AQUISITION RADAR	ASSEMBLE ANT. REFLECTOR	1.80	1.30	2.30
PULSE AQUISITION RADAR	INSTALL ANT. REFLECTOR	1.00	0.80	1.20
PULSE AQUISITION RADAR	ENERGIZE PAR	0.80	0.30	1.30
PULSE AQUISITION RADAR	MARCH ORDER PAR	1.50	1.30	1.60
PULSE AQUISITION RADAR	STOW OMNI DIRECTIONAL ANT.	1.50	1.30	1.60
PULSE AQUISITION RADAR	STOW ANT. REFLECTOR	1.30	1.00	1.50
Power Pack	REPLACE BATTERY AND ENGINE ACC	1.70	1.40	1.90
Power Pack	REPLACE POWER PACK	1.00	0.50	1.50
RECOVER M60A3 TANK	POSITION M88	2.30	1.40	3.30
RECOVER M60A3 TANK	OPEN GRILL DOORS	1.30	1.00	1.70
RECOVER M60A3 TANK	DISCONNECT FINAL DRIVES	2.30	1.20	3.30
RECOVER M60A3 TANK	SECURE DOORS	2.30	1.30	3.20
REMOVE/REPLACE M901 ITV TRAVER	REMOVE OUTER GEAR SNAP RING	1.90	1.50	2.30
REMOVE/REPLACE M901 ITV TRAVER	REMOVE GEAR	2.10	1.70	2.60
REMOVE/REPLACE M901 ITV TRAVER	REASSEMBLE GEARS AND REPLACE	1.70	1.20	2.30
REMOVE/REPLACE M901 ITV TRAVER	REPLACE OUTER GEAR SNAP RING	2.80	1.80	3.80

Performance DBase System
U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland, USA

Task	Sub-Task	Correction Factor (CF)	Probable Range	
REPAIR M60 MACHINE GUN	REMOVE/DISASSEMBLE BARREL GROU	1.40	1.30	1.60
REPAIR M60 MACHINE GUN	REPLACE/REASSEMBLE BARREL GROU	1.50	1.40	1.70
REPAIR M60 MACHINE GUN	REMOVE/DISASSEMBLE TRIGGER ASS	1.60	1.50	1.80
REPAIR M60 MACHINE GUN	REPLACE/REASSEMBLE TRIGGER ASS	2.70	2.30	3.10
SIGNAL OPERATIONS	INSTALL AN/GGC	1.60	1.20	2.10
SIGNAL OPERATIONS	ERECT CAMOUFLAGE NETS	1.20	0.90	1.60
SIGNAL OPERATIONS	PREPARE GENERATOR	0.40	0.10	0.80
SIGNAL OPERATIONS	BREAK DOWN RATT STATION	0.90	0.60	1.30
SIGNAL OPERATIONS	INSTALL AN/MRC 138	1.30	0.80	1.80

APPENDIX B

Methodology for Calculating Correction Factors

Methodology for Calculating Correction Factors

Regression analyses are used to quantify the relationship between variables where the value of one is affected by changes in others. The type of uniform worn and whether or not the event was completed for the first time, either in Battle Dress Uniform (BDU) or Mission Oriented Protective Posture (MOPP) level IV, all equipment worn and sealed, are independent variables. A multiple linear regression allows a dependent variable to be estimated by quantifying the relationship to several independent variables. In this instance, time to complete a task is the affected or dependent variable. Interactions and variables not measured are reflected in the error term and include such effects as team work and leadership. An estimate of how well the regression estimates the dependent variable is expressed by the multiple correlation coefficient. Analysis then can be used to determine the effect of MOPPIV and the first time effect on the total time to complete a task.

For troop performance studies the regression expression is represented by:

$$T = T_o + a(x) + b(y) + e \qquad \text{(B-1)}$$

where "T" (the dependent variable) is the total time in minutes to complete a task, "T_o," (the intercept) is the practiced, unencumbered time, "x" (first independent variable) is the clothing type, "y" (second independent variable) is the order in which an event was started and "e" is the error term. Because it is assumed that the clothing contribution would be zero for wearing BDUs, "x" is represented by either a "0" or a "1." Likewise, if a team was working an event for the first time "y" would be assigned a "1" and if the team has completed the event before a "0" would be assigned since no first time effect would be present. The expression, without the error term, then becomes:

$$T = T_o + a + b \qquad \text{(B-2)}$$

Where "a" and "b" represent the correction in minutes for MOPPIV and practiced factors, respectively. Therefore, a team completing an event for the first time in BDU is expressed as:

$$T = T_o + b \qquad \text{(B-3)}$$

A team performing an event in BDU two or more times would be represented as "T_o," ($T = T_o$). By wearing MOPPIV this team would add a clothing correction for MOPPIV and be expressed as:

$$T = T_o + a \qquad \text{(B-4)}$$

The event time for the same team completing the event for the first time and wearing MOPPIV would be expressed as:

$$T = T_o + a + b \qquad \text{(B-5)}$$

An example case will be replacing the shroud during the removing/replacing of the M60A3 transmission, accomplished during the Maintenance Evaluation completed under moderate temperature. All other tasks and events were likewise evaluated and are included in the results.

Replacing the shroud includes the placement of the shroud on the powerpack and the connection of the attachment bolts. The data for evaluation is given in Table B-1, where team 1 replaced the shroud twice with the first occurrence in BDU in 7.8 minutes and the second occurrence in MOPPIV in 14.2 minutes. For this example, the resulting regression coefficients in Table B-2, are "T_o", the practiced, unencumbered time, "a", the additional time for MOPPIV, plus or minus the standard deviation and "b", the additional time needed if the event is done for the first time, plus or minus the standard deviation. Thus, the expected time for replacing the shroud is 5.8 minutes for a practiced unencumbered team. An additional 3.8 minutes is added to the total if the team was wearing MOPPIV, for an expected time of 9.6 minutes. This additional MOPPIV time could be as much as 11.5 minutes (9.6+1.9) or as little as 7.7 minutes (9.6-1.9). No correction is required for the first time effect because, in this example, the coefficient is negative (Table B-2). In other events this first time correction is calculated the same as for the MOPPIV effect.

TABLE B-1. Data Used in Example Regression

Team	BDU	MOPPIV	1st Time
1	7.8	14.2	BDU
2	4.6	24.6*	MOPP
3	5.8	10.2	BDU
4	6.4	7.4	MOPP**
5	3.6	6.3	MOPP

* Data excluded due to the removal of items not associated with trial.
** Team is practiced in both uniforms.

TABLE B-2. Regression Coefficients for Example

Coefficients
T_o = 5.8
a = 3.8±1.9
b = -0.5±2.0

The quotient resulting from "$T_o/(T_o + a)$" represents the degradation for wearing MOPPIV. That is, the unencumbered practiced time "T_o" divided by the total time for MOPPIV "$T_o + a$." Thus a team replacing the shroud in MOPPIV is degraded to 60 percent of their practiced, unencumbered ability, 5.8/(5.8+3.8)=0.60 (Table B-3). In a similar calculation, the degradation for doing the job for the first time results from the quotient of "$T_o/(T_o+b)$." In this example no degradation was determined for doing the event for the first time. A team is degraded to 0.63 if replacing the shroud for the first time and in MOPPIV, where both MOPPIV and first time coefficients are added in the denominator, i.e. "T_o/T_o+a+b." The quantity "$(T_o+a)/T_o$" (which is the inverse of the degradation factor) is called the MOPPIV Correction Factor. This factor when multiplied by "T_o" gives the expected time to complete a task in MOPPIV. For this example the correction factor is 1.66. A probable range is determined by making the correction factor calculation using plus or minus the standard deviation, given for each coefficient. The estimated time for this event is then 5.8x1.66 or 9.6 minutes. The results give a real number estimate of the effect of MOPPIV on this job performance (Table B-4).

TABLE B-3. Calculations for Example

Calculations
$T_o = 5.8$
$T_o + a = 9.6$
$T_o + b = 5.3$
$T_o + a + b = 9.1$
$T_o/(T_o + a) = 0.60$
$(T_o+a)/T_o = 1.66$
$T_o/(T_o + b) = 1.09$
$a/T_o = 0.66$

TABLE B-4. Example Results

Effect of Wearing MOPPIV on Replacing the Shroud	
Degraded Effectiveness	0.60
MOPPIV Correction Factor Probable Range	1.7 1.3-2.0

APPENDIX C

Standardized Human Factor Listing

Human Factors Listing and Definitions

Human Skills and Sub-skills

I. COMMUNICATION SKILLS (COM)

A01. SPEECH COMPREHENSION This is the ability to understand spoken English words and sentences.

A02. READING COMPREHENSION This is the ability to understand written sentences and paragraphs.

A03. SPEECH EXPRESSION This is the ability to use English words or sentences in speaking so others will understand.

A04. WRITTEN EXPRESSION This is the ability to use English words or sentences in writing so others will understand.

A05. AUDITORY ATTENTION This is the ability to focus on a single source of auditory information in the presence of other distracting and irrelevant auditory stimuli.

A06. SPEECH CLARITY This is the ability to communicate orally in a clear fashion that is understandable to a listener.

II. NUMERICAL DATA SKILLS (NUM)

A07. MEMORIZATION This is the ability to remember information, such as words, numbers, pictures, procedures. Pieces of information can be remembered by themselves or with other pieces of information.

A08. NUMBER FACILITY This ability involves the degree to which adding, subtracting, multiplying and dividing can be done quickly and correctly. These can be steps in other operations like finding percents and taking square roots.

III. DECISION MAKING SKILLS (DMS)

A09. PROBLEM SENSITIVITY This is the ability to tell when something is wrong or is likely to go wrong. It includes being able to identify the whole problem as well as the elements of the problem.

A10. DEDUCTIVE REASONING This is the ability to apply general rules to specific problems to come up with logical answers. It involves deciding if an answer makes sense.

A11. INDUCTIVE REASONING This is the ability to combine separate pieces of information, or specific answers to problems, to form general rules or conclusions. This involves the ability

to think of possible reasons why things go together.

A12. INFORMATION ORDERING This is the ability to correctly follow a rule or set of rules to arrange things or actions in a certain order. The rule or set of rules to be used must already be given. The things or actions to be put in order can include numbers, letters, words, pictures, procedures, sentences, and mathematical or logical operations.

IV. PRECISION CONTROL SKILLS (PER)

A13. MANUAL DEXTERITY This is the ability to make skillful, coordinated movements of one hand, a hand together with its arm, or two hands to grasp, place, move or assemble objects like hand tools or blocks. This ability involves the degree to which these arm-hand movements can be carried out quickly. It does not involve moving machine or equipment controls like levers.

A14. FINGER DEXTERITY This is the ability to make skillful, coordinated movements of the fingers of one or both hands and to grasp, place or move small objects. This ability involves the degree to which these finger movements can be carried out quickly.

A15. WRIST-FINGER SPEED This is the ability to make fast simple, repeated movements of the fingers, hands and wrists. It involves little, if any, accuracy or eye-hand coordination.

V. MOVEMENT AND COORDINATION (MOV)

A16. EXTENT FLEXIBILITY This is the ability to bend, stretch, twist or reach out with the body, arms or legs.

A17. DYNAMIC FLEXIBILITY This is the ability to bend, stretch, twist or reach out with the body, arms and/or legs both quickly and repeatedly.

A18. GROSS BODY COORDINATION This is the ability to coordinate the movement of the arms, legs and torso together in activities where the whole body is in motion.

A19. GROSS BODY EQUILIBRIUM This is the ability to keep or regain one's body balance, or to stay upright when in an unstable position. This ability includes being able to maintain one's balance when changing direction while moving or when standing motionless.

VI. ATTENTION AND QUICKNESS (ATT)

A20. REACTION TIME This is the ability to give one fast response to one signal (sound, light, picture, etc.) when it appears. This ability is concerned with the speed with which the movement can be started with the hand, foot, etc.

A21. SPEED OF LIMB MOVEMENT This ability involves the speed with which a single movement of the arms or legs can be made. This ability does not include accuracy, careful control or coordination of movement.

A22. SELECTIVE ATTENTION This is the ability to concentrate on a task one is doing and not be distracted. When distraction is present, it is not part of the task being done. This ability also involves concentrating while performing a boring task.

A23. DIVIDED ATTENTION This is the ability to shift back and forth between two or more sources of information.

VII. VISUAL PATTERN (VIN)

A24. SPEED OF CLOSURE This ability involves the degree to which different pieces of information can be combined and organized into one meaningful pattern quickly. It is not known beforehand what the pattern will be. The material may be visual or auditory.

A25. FLEXIBILITY OF CLOSURE This is the ability to identify or detect a known pattern (like a figure, word, object) which is hidden in other material. The task is to pick out the pattern you are looking for from the background material.

A26. SPATIAL ORIENTATION This is the ability to tell where you are in relation to the location of some object or to tell where the object is in relation to you.

A27. VISUALIZATION This is the ability to imagine how something will look when it is moved around or when its parts are moved or rearranged. It requires the forming of mental images of what patterns or objects would look like after certain changes such as unfolding or rotation. One has to predict what an object, set of objects or pattern would look like after the changes were carried out.

A28. PERCEPTUAL SPEED This ability involves the degree to which one can compare letters, numbers, objects, pictures or patterns, both quickly and accurately. The things to be compared may be presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.

VIII. MANUAL CONTROL SKILLS (MAN)

A29. CONTROL PRECISION This is the ability to move controls of a machine or vehicle. This involves the degree to which these controls can be quickly and repeatedly moved to exact positions.

A30. MULTILIMB COORDINATION This is the ability to coordinate movements of two or more limbs (for example, two arms, two legs

or one leg and one arm) together, such as in moving equipment controls. Two or more limbs are in motion, while the individual is sitting, standing or lying down.

A31. RATE CONTROL This is the ability to adjust an equipment control in response to changes in the speed and/or direction of a continuously moving object or scene. The ability involves timing these adjustments in anticipating these changes. This ability does not extend to situations in which both the speed and direction of the object are perfectly predictable.

A32. ARM-HAND STEADINESS This is the ability to keep the hand and arm steady. It includes steadiness while making an arm movement as well as while holding the arm and hand in one position. This ability does not involve strength or speed.

IX. STRENGTH AND STAMINA (STR)

A33. STAMINA This is the ability of the lungs an circulatory (blood) systems of the body to perform efficiently over long time periods. This is the ability to exert oneself physically without getting out of breath.

A34. STATIC STRENGTH This is the ability to use muscle force in order to lift, push, pull or carry objects. It is the maximum force that one can exert for a brief period of time.

A35. EXPLOSIVE STRENGTH This is the ability to use short bursts of muscle force to propel oneself or an object. It requires gathering energy for bursts of muscle effort over a very short time period.

A36. DYNAMIC STRENGTH This is the ability of the muscles to exert force repeatedly or continuously over a long time period. This is the ability to support, hold up, or move the body's own weight and/or objects repeatedly over time. It represents muscular endurance and emphasizes the resistance of the muscles to fatigue.

A37. TRUNK STRENGTH This ability involves the degree to which one's stomach and lower back muscles can support part of the body repeatedly or continuously over time. The ability involves the degree to which these trunk muscles do not "give out," or fatigue, when they are put under such repeated or continuous strain.

X. VISION (VIS)

A38. NEAR VISION This is the capacity to see close environmental surroundings.

A39. FAR VISION This is the capacity to see distant environmental surroundings.

A40. VISUAL COLOR DISCRIMINATION This is the capacity to match or discriminate between colors. This capacity also includes detecting differences in color purity (saturation) and brightness (brilliance).

A41. NIGHT VISION This is the ability to see under low light conditions.

A42. PERIPHERAL VISION This is the ability to perceive objects or movement towards the edges of the visual field.

APPENDIX D

Including New Data into the DBase

Including New Data into the Performance DBase System

Addition of data into the Performance DBase is an important means of keeping the system current with changes in technology and with performance data from tasks completed while wearing IPE. The form of the data required is indicated in Figure D-1. The collector of data is required to fill out the data sheet and provide some basic information and complete some analysis before new data can be entered into the system. When available, the collector of the data should forward a technical report of the event for further reference. Basically, the task description, name, subtasks contained within the task, the calculated correction factor and its probable range are needed. The methodology for calculating the correction factor should be noted if different from established methods. Finally, several items of additional information is required, these should be circled to indicate such items as crew size, temperature, time wearing IPE and task type.

For the purposes of standardizing the catagory of tasks, the following definitions are given for the condition categories. Congnitive tasks are those which rely upon a soldier/airman to reason or require skills such as: memory, speech, color discrimination, peripheral vision, attention, concentration and similar identifiers. Motor skills are typically divided into two groups, fine motor and gross motor. Fine motor skills include those tasks which require finger manipulation, finger response, or fine motor strength. For example, are bomb build-up or using switches or keyboards. Gross motor skills are those tasks which require use of large muscle groups, general mobility, and gross muscle strength. For example, pulling a power pack on a tank or lifting a heat-seeking missile to an aircraft. For combat operations the three groups, high, medium and low are defined as follows: High rate represents maximum effort for either offense or defense. These are usually represented by high intensity battle, active defense, surprise ambushes, extreme fire mission requirements, emergency resupply and emergency maintenance. Medium rate includes such tasks as convoy, road march, patrolling, preparation fires, movement of supply points, patient care and general support maintenance. Low rate represents those tasks which include reserve activities, rear area security, harassing fires, physical exams and logistic support.

The data sheet should be filled out, supporting documentation attached and returned to the US Army Ballistic Research Laboratory, the address is on the data sheet. The data will be reviewed and added to the DBase as appropriate. A new version of the Performance DBase System will be released as it is updated.

PERFORMANCE DBASE SYSTEM
REQUIREMENT DATA SHEET

SENDER: ____________________
____
____

TO: U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground, Maryland 21005 USA

Task name: ____________________ Sub-Task: ____________________

Correction Factor (CF): ____________ Probable Range (PR): ________ to ________

Circle appropriate response:

Crew Size: Individual, team, squad, platoon, company, battalion

Temperature: Extremely cold, very cold, cold, cool, warm, hot, very hot, Extremely hot.

Time wearing IPE (HRS): 0-3, 3-6, 6-12, 24-48, 48-72, 72+

Task Type: Cognitive, Gross Motor Skill, Fine Motor Skill, Low Combat, Medium Combat, High Combat.

Human Skills:	SUB-SKILL:	Human Skill:	SUB-SKILL:
I. Communication:	R01, R02, R03, R04, R05, R06	VI. Attention/Quickness:	R20, R21, R22, R23
II. Numerical Data:	R07, R08	VII. Visual Pattern:	R24, R25, R26, R27, R28
III. Decision Making:	R09, R10, R11, R12	VIII. Manual Control:	R29, R30, R31, R32
IV. Precision Control:	R13, R14, R15	IX. Strength/Stamina:	R33, R34, R35, R36, R37
V. Movement/Coordination:	R16, R17, R18, R19	X. Vision:	R38, R39, R40, R41, R42

Figure D-1. Requirement data sheet for reporting data for addition to the Performance DBase system.

APPENDIX E

Procedure for Obtaining the Program Disk

Performance DBase System

U.S. Army Ballistic Research Laboratory
Vulnerability/Lethality Division
Aberdeen Proving Ground
Maryland 21005

To obtain the program disk for operating the Performance DBase System, write to the above address in care of the author. The DBase System operates on any standard IBM or compatible computer.

DISTRIBUTION LIST

No. of Copies	Organization
1	Office of the Secretary of Defense OATSD(AE) (Chemical Matters) Washington, DC 20301
1	Department of Defense OUSDRE(ELS) Room 3/D129, Pentagon Washington, DC 20301
1	Organization of Joint Chiefs of Staff ATTN: J-3 JOD (COL Tripler) Washington, DC 20301
4	Director Defense Intelligence Agency ATTN: DT-5A ATTN: DX-7B ATTN: DB-4G1 ATTN: DB-1B2 Washington, DC 20301
1	Director Armed Forces Medical Intelligence Center ATTN: AFMIC-ZA Fort Detrick, Frederick, MD 21701
1	Commander in Chief U.S. European Command ATTN: ECJ5-N APO New York 09128
1	Commander in Chief Pacific ATTN: J5414 (Box 15) Camp Smith, HI 96861
1	Commander in Chief U.S. Atantic Fleet ATTN: J338 Norfolk, VA 23511
1	Commander in Chief U.S. Southern Command ATTN: SCJ3 APO Miami 34004
1	Commander in Chief U.S. Central Command ATTN: CCJ3-X MacDill AFB, FL 33608-7001
1	Commander in Chief U.S. Special Operations Command ATTN: SOJ3-05 (Chemical Officer) MacDill AFB, FL 33608
1	Commander U.S. Forces Japan ATTN: J3 APO San Francisco 96301
1	Commander U.S. Forces Korea ATTN: CJ-PL-N APO Sanfrancisco 96301
10	C.I.A. OIR/DB/Standard GE47 HQ Washington, DC 20505
2	Administrator Defense Technical Information Center ATTN: DTIC-FDAC Cameron Station, Bldg 5 Alexandria, VA 22304-6145
3	HQDA ATTN: DAMA-ART-M ATTN: DASG-HCD-D (LTC Myers) ATTN: DAMO-SWC (LTC Brown) Washington, DC 20310-2300
3	Commander in Chief U.S. Army Europe ATTN: AEAGC-NC-C APO New York 09403
3	Commander U.S. Army Materiel Command ATTN: AMCDRA-ST ATTN: AMCCN-M ATTN: AMCCN-C 5001 Eisenhower Avenue Alexandria, VA 22333-0001

DISTRIBUTION LIST

No. of Copies	Organization
8	Commander U.S. Army Armament Research, Development and Engineering Center ATTN: SMCAR-MSI Dover, NJ 07801-5001
2	Commander U.S. Army Training and Doctrine Command ATTN: ATCD-N ATTN: ATCD-T Fort Monroe, VA 23651
1	Commander U.S. Army Forces Command ATTN: AFOP-TN Fort McPherson, GA 30330
1	Commander U.S. Army Western Command ATTN: APO-NC ATTN: APLG-MU Fort Shafter, HI 96858 Dover, NJ 07801-5001
1	Commander CFA (ROK/US) ATTN: C3-NBC APO Sanfrancisco 96301
1	Commander U.S. Army Logistics Center ATTN: ATCL-MN Fort Lee, VA 23801
1	Commander U.S. Army Transportation Center and Fort Eustis ATTN: ATSP-PD-C (Chemical Officer) Fort Eustis, VA 23604
1	Commander U.S. Army Aviation Center ATTN: ATZQ-D-MS Fort Rucker, AL 36362

No. of Copies	Organization
1	Commander U.S. Army Foreign Science and Technology Center ATTN: AIAST-RA-ID2 220 Seventh Street NE Charlottesville, VA 22901
5	Commander Army Natick R&D Center ATTN: STRNC-AC ATTN: STRNC-I ATTN: STRNC-U ATTN: STRNC-YA ATTN: STRNC-W Natick, MA 01760
1	Commander USAJFKSWC ATTN: ATSU-CD-CS Fort Bragg, NC 28307-5000
5	Commandant U.S. Army Chemical School ATTN: ATZN-CM-FECD ATTN: ATZN-CM-CS ATTN: ATZN-CM-CT ATTN: ATZN-CM-CC ATTN: ATZN-CM-NF Fort McClellan, AL 36205
1	Commandant U.S. Army Quartermaster School ATTN: ATSM-CDC Fort Lee, Virginia 23801-5037
4	Commander U.S. Army Nuclear and Chemical Agency ATTN: MONA-NU ATTN: MONA-CM ATTN: MONA-WE ATTN: MONA-SAL 7500 Backlick Road (Building 2073) Springfield, VA 22150
2	Commander U.S. Army TRADOC Analysis Center ATTN: ATRC-WDB ATTN: ATRC-TSL White Sands Missile Range, NM 88002

DISTRIBUTION LIST

No. of Copies	Organization
1	Director U.S. Army TRADOC Analysis Command ATTN: ATRC-FWW ATTN: ATZL-TIE Fort Leavenworth, KS 66027-5200
1	President U.S. Army Armor & Engineer Board ATTN: ATZK-AE-TR Fort Knox, KY 40121-5470
1	Commanding General Wright Patterson Air Force Base ATTN: AFAMRL-HE Dayton, OH 45433
1	Commander U.S. Army ARDEC ATTN: SMCAR-TDC Dover, NJ 07801-5001
1	Director U.S. AMCCOM ARDEC CCAC Benet Weapons Laboratory ATTN: SMCAR-CCB-TL Watervliet, NY 12189-4050
1	Commander U.S. Army Armament, Munitions and Chemical Command ATTN: AMSMC-IMP-L Rock Island, IL 61299-7300
1	Commander U.S. Army Aviation Systems Command ATTN: AMSAV-ES 4300 Goodfellow Blvd St. Louis, MO 63120-1798
4	Commander U.S. Army Dugway Proving Ground ATTN: STEDP-SD-TA-F ATTN: STEDP-SD-TA ATTN: STEDP-MT-CA-CB ATTN: STEDP-MT-C Dugway, UT 84022
1	Director U.S. Army Air Aviation Research and Technology Activity Ames Research Center Moffett Field, CA 94035-1099
1	Commander U.S. Army Communications - Electronics Command ATTN: AMSEL-ED Fort Monmouth, NJ 07703-5301
1	Commander CECOM R&D Technical Library ATTN: AMSEL-IM-L (Reports Section) B 2700 Fort Monmouth, NJ 07703-5000
1	Commander U.S. Army Missile Command Research Development and Engineering Center ATTN: AMSMI-RD Redstone Arsenal, AL 35898-5241
1	Director U.S. Army Missile and Space Intelligence Center ATTN: AIAMS-YDL Redstone Arsenal, AL 35898-5500
1	Commander U.S. Army Tank Automotive Command ATTN: AMSTA-TSL Warren, MI 48397-5000
1	Commandant U.S. Army Infantry School ATTN: ATSH-CD-CS-OR Fort Benning, GA 31905-5400
1	Commander U.S. Army Development and Employment Agency ATTN: MODE-ORO Fort Lewis, WA 98433-5000

DISTRIBUTION LIST

No. of Copies	Organization
2	Commandant U.S. Marine Corps ATTN: POG-31 ATTN: APW Room 2318, Arlington Annex Arlington, VA 20380
1	Battelle Edgewood Operations ATTN: F.T. Crimmins, DIR CBIAC 2113 Emmorton Park Road Edgewood, MD 21040
1	AFWL/SUL Kirtland AFB, NM 87117
1	Air Force Armament Laboratory ATTN: AFATL/DLODL (Tech Info Center) Eglin AFB, NM 32542-5438
1	AFELM, The Rand Corporation ATTN: Library-D 1700 Main Street Santa Monica, CA 90406

Aberdeen Proving Ground

Dir, USAMSAA
ATTN: AMXSY-D
AMXSY-MP
Cdr, USATECOM
ATTN: AMSTE-SI-F
ATTN: SMSTE-TE-T
Cdr, CRDEC
ATTN: SMCCR-RSP
SMCCR-RSP-A
SMCCR-MU
SMCCR-SPS-IL
SMCCR-TD
SMCCR-TDT (Mr. Lawhorne)
SMCCR-ST
SMCCR-PPD
SMCCR-OPR
SMCCR-NB
Cdt, USAOC&S
ATTN: ATSL-CDT
ATSL-CD
ATSL-CD-CS
Dir, USAHEL
ATTN: SLCHE-CC-LH

USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. BRL Report Number ______________________ Date of Report __________

2. Date Report Received ______________________

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.) ______________________

4. How specifically, is the report being used? (Information source, design data, procedure, source of ideas, etc.) ______________________

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided or efficiencies achieved, etc? If so, please elaborate. ______________________

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.)

CURRENT ADDRESS

Name

Organization

Address

City, State, Zip

7. If indicating a Change of Address or Address Correction, please provide the New or Correct Address in Block 6 above and the Old or Incorrect address below.

OLD ADDRESS

Name

Organization

Address

City, State, Zip

(Remove this sheet, fold as indicated, staple or tape closed, and mail.)

— — — — — — — — — — — FOLD HERE — — — — — — — — — — — —

Director
US Army Ballistic Research Laboratory
ATTN: DRXBR-OD-ST
Aberdeen Proving Ground, MD 21005-5066

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 12062 WASHINGTON, DC

POSTAGE WILL BE PAID BY DEPARTMENT OF THE ARMY

Director
US Army Ballistic Research Laboratory
ATTN: DRXBR-OD-ST
Aberdeen Proving Ground, MD 21005-9989

— — — — — — — — — — — FOLD HERE — — — — — — — — — — — —

END
DATE
FILMED
6-88
DTIC